

## **SP-W6 Project Effects on Temperature Regime**

*October 25, 2002*

### **1.0 Introduction/Background**

Existing and future operation of the Oroville Facilities may have effects on the temperature goals and objectives for the Feather River. Issues raised at public meetings include: effects of existing and future project facilities and operations on thermal stratification and other thermal processes on project waters, including availability of cold water for release in various water year types under current and future operational demands (W9); effects of existing and future water releases and operations on water temperatures in the Diversion Pool, Forebay, Afterbay, Oroville Wildlife Area, low-flow section of the river and downstream areas; at the hatchery; for agriculture; and the quality and availability of habitat for salmonids and other aquatic resources (W10); existing and future project compliance with temperature requirements of the SWP Feather River Flow Constraints and effectiveness of constraints for a) protection of salmonids in the low-flow and high-flow sections of the Feather River, b) hatchery operation, and c) agricultural operations (W11); effects of existing and future project facilities and operations on access to the cold water pool during below normal water years and multiple below normal water years under existing and future operational demands, and effectiveness of the Temperature Control Device in providing access (W12); effects of existing and future hatchery operations on water quality and water temperatures in the Feather River and Afterbay (W13); and effects of existing and future pump-back operations on water quality and water temperatures in Lake Oroville, Diversion Pool, Thermalito Forebay, Thermalito Afterbay, and Oroville Wildlife Area, habitat suitability, and outmigration for salmonids (W14).

Some temperature data have been collected from the North, Middle, and South forks of the Feather River near their confluences with Lake Oroville, from the reservoir itself, and downstream from Oroville Dam in the Feather River, Thermalito Power Canal, and Thermalito Afterbay. However, these data are not sufficient to determine compliance with all Basin Plan objectives, goals, and criteria for the designated beneficial uses. Additional temperature data and analyses are needed to demonstrate project compliance with Basin Plan objectives, commitments, and other requirements.

### **2.0 Study Objective**

The objectives of the study are to evaluate effects of project facilities and operations on the temperature regime of project waters and waters affected by the project, and the ability of the project to meet the temperature requirements for protection of beneficial uses, including agriculture, fish, and other aquatic resources.

### **3.0 Relationship to Relicensing /Need for the Study**

Construction of Oroville Dam resulted in an altered thermal regime of waters within the project boundary and downstream in the Feather River. These temperature changes can affect the ecosystem

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and beneficial uses of water released downstream. In addition, large shallow water bodies such as the Thermalito Forebay and Afterbay may affect water quality by providing water temperatures that facilitate conversion of sediment-bound metals (e.g., mercury) to bioavailable forms (e.g., methyl mercury), which can have effects on the aquatic food chain, wildlife, and humans.

Prior to issuance of a new license for the project, the Federal Energy Regulatory Commission (FERC) will require a water quality certification by the State Water Resources Control Board (SWRCB). The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the Central Valley Regional Water Quality Control Board's (CVRWQCB) Basin Plan, which includes water quality objectives for protection of designated beneficial uses. The CVRWQCB has established surface water quality objectives for temperature. In addition, the California Department of Water Resources (DWR) has agreements with the Department of Fish and Game (DFG) for temperature objectives for the Feather River Fish Hatchery and with several water districts for temperature objectives for irrigation. The National Marine Fisheries Service (NMFS) has also identified temporary temperature goals in the Feather River downstream from Oroville Dam for salmonids that are listed under the federal Endangered Species Act.

Information obtained from the study will be used to determine the ability of the project to meet water temperature requirements, and the need for project modification or mitigation for impacts to water temperature from project operations. This analysis is required for water quality certification by the SWRCB. The water quality certification is needed to file with the application for license renewal with FERC.

#### **4.0 Study Area**

The study area is generally within the FERC project boundary, but also includes the Feather River downstream to the confluence with the Sacramento River. Specific water bodies included in the study plan are the North, Middle, and South Forks and West Branch of the Feather River, Concow Creek, Lake Oroville, Feather River downstream from Oroville Dam to the confluence with the Sacramento River, Thermalito Diversion Pool, Forebay, and Afterbay, and Oroville Wildlife Area ponds.

Study plans approved by the Environmental Work Group define the limits of the study area. If initial study results indicate that the study area should be expanded or contracted, the Environmental Work Group will discuss the basis for change and revise the study area as appropriate.

#### **5.0 General Approach**

##### **Task 1— Thermal Regime of Project Waters**

Determination of existing project effects on thermal processes in project waters will involve empirical analysis of temperature data, while evaluation of future project effects will require development and calibration of a temperature model to simulate conditions. Where historic and current temperature data are not sufficient to evaluate project effects under various hydrologic conditions, the temperature

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model will be used to simulate temperature conditions for analysis. Output from the temperature model will provide information for a greater range of operations than may be able to be empirically analyzed.

This study plan is responsible for collecting temperature data for empirical analyses of current conditions and providing data for calibration of the temperature models being developed in Engineering and Operations study plans. This study will provide information for calibration of the temperature models for the Oroville Reservoir (study plan SP-E1.3), Thermalito Complex (study plan SP-E1.4), Feather River (study plan SP-E1.5), Oroville Reservoir cold water pool evaluation (study plan SP-E7), and evaluation of pumpback operations (study plan SP-E8). If initial study results indicate that the methods and tasks should be modified, the Environmental Work Group will discuss the basis for change and revise the study plans as appropriate.

#### Task 1A—Existing Project Effects on Thermal Regime of Project Waters

Some existing temperature data have been collected from the tributaries to the reservoir, Lake Oroville, Feather River downstream from Oroville Dam, and Thermalito Afterbay Outlet to the Feather River and Western Canal. These data will be compiled into a computer database for access and evaluation.

Additional temperature data will be collected at the existing monitoring sites as well as other sites to provide information needed for analyses of project effects on the thermal regime of project waters, document thermal conditions affecting salmonids (such as in spawning, rearing, or migration areas) or other aquatic life, identify sources of thermal change or stress, and provide information for calibration of temperature models. Continuously recording loggers (Onset Optic Stowaway) will be used to record temperatures at 15-minute intervals at river or discharge (e.g., hatchery, Thermalito Afterbay Outlet) monitoring locations (Table SPW6-1, Figure SPW6-1). Redundant recorders will be placed on opposite banks at sites most subject to vandalism to reduce potential loss of data. Temperature loggers will be serviced and data downloaded to lap top computers at intervals not exceeding monthly, but more frequently at sites where recorder loss is prevalent.

Temperatures will be measured with a thermistor in spawning areas and at half-meter intervals in deeper pools in the Feather River downstream from the dam for determination of effects of project flows on thermal conditions including stratification. Temperatures will be measured bi-weekly from late spring (May) to the fall (October), and monthly from late fall (November) through early spring (April).

Water temperatures will be measured from the surface to the bottom at monthly intervals during the winter and biweekly from spring to fall in impounded waters (Lake Oroville, Thermalito Diversion Pool, Forebay, and Afterbay, and Fish Barrier Pool) and ponds in the Oroville Wildlife Area. Temperature profiles will be measured in Lake Oroville with a thermistor at meter intervals when temperature differences are observed between successive depth measurements, and at three to five meter intervals when temperatures are uniform between depths. Temperature profiles will be measured at half to one-meter intervals in the other water bodies from the surface to the bottom using a thermistor. Cross section measurements will also be conducted at the Forebay and Afterbay to determine variation in temperatures in shallower and deeper areas, arms, and bays.

Existing and newly collected data will be evaluated to determine thermal processes in Lake Oroville, Thermalito Diversion Pool, Forebay, and Afterbay, Fish Barrier Pool, Oroville Wildlife Area ponds, and the Feather River. Temperature data and the depth-capacity curve for the reservoir will be used to evaluate the extent of the cold water pool under existing project operations. Temperature data from the river will be used to evaluate existing effects from the hatchery and Thermalito Afterbay Outlet.

**Table SPW6-1. Temperature Measurement Sites in Project and Downstream Waters**

	<b>Location</b>	<b>Measurement Method</b>	<b>Rationale</b>
<b>1</b>	<b>West Branch near gage</b>	<b>Recorder</b>	<b>a,b</b>
<b>2</b>	<b>West Branch at Oroville Reservoir</b>	<b>Recorder</b>	<b>a,b,c</b>
<b>3</b>	<b>Concow Cr at Jordan Hill Road</b>	<b>Recorder</b>	<b>a,b</b>
<b>4</b>	<b>Concow Creek at Oroville Reservoir</b>	<b>Recorder</b>	<b>a,b,c</b>
<b>5</b>	<b>North Fork near Poe Dam</b>	<b>Recorder</b>	<b>a,b</b>
<b>6</b>	<b>North Fork at Oroville Reservoir</b>	<b>Recorder</b>	<b>a,b,c</b>
<b>7</b>	<b>French Creek</b>	<b>Recorder</b>	<b>a,b,c,d</b>
<b>8</b>	<b>Middle Fork at Milsap Bar Road</b>	<b>Recorder</b>	<b>a,b</b>
<b>9</b>	<b>Middle Fork at Oroville Reservoir</b>	<b>Recorder</b>	<b>a,b,c</b>
<b>10</b>	<b>Fall River</b>	<b>Recorder</b>	<b>c</b>
<b>11</b>	<b>South Fork</b>	<b>Recorder</b>	<b>c</b>
<b>12</b>	<b>Ponderosa Reservoir</b>	<b>Profile</b>	<b>c</b>
<b>13</b>	<b>Sucker Run</b>	<b>Recorder</b>	<b>a,b,c,d</b>
<b>14</b>	<b>North Fork Arm Lake Oroville</b>	<b>Profile</b>	<b>b,e</b>
<b>15</b>	<b>Middle Fork Arm Lake Oroville</b>	<b>Profile</b>	<b>b,e</b>
<b>16</b>	<b>South Fork Arm Lake Oroville</b>	<b>Profile</b>	<b>b,e</b>
<b>17</b>	<b>Lake Oroville Main Body</b>	<b>Profile</b>	<b>b,e</b>
<b>18</b>	<b>Lake Oroville near Dam</b>	<b>Profile</b>	<b>b,e</b>
<b>19</b>	<b>Lake Oroville Intake Structure</b>	<b>Sensors/SCADA</b>	<b>e,f</b>
<b>20</b>	<b>Hyatt tailrace</b>	<b>Sensor/SCADA</b>	<b>e</b>
<b>21</b>	<b>Diversion Pool upstream from Kelly Ridge PH discharge</b>	<b>Profile</b>	<b>e</b>
<b>22</b>	<b>Kelly Ridge PH Discharge</b>	<b>Recorder</b>	<b>e</b>
<b>23</b>	<b>Diversion Pool downstream from Kelly Ridge PH discharge</b>	<b>Profile</b>	<b>e</b>
<b>24</b>	<b>Glen Pond</b>	<b>Profile</b>	<b>a, b</b>
<b>25</b>	<b>Glen Creek</b>	<b>Recorder</b>	<b>a, b</b>
<b>26</b>	<b>Diversion Pool near Diversion Dam</b>	<b>Profile</b>	<b>e</b>
<b>27</b>	<b>Diversion Dam Power Plant</b>	<b>Sensor/SCADA</b>	<b>e</b>
<b>28</b>	<b>Thermalito Power Canal at Diversion Pool</b>	<b>Sensor/SCADA</b>	<b>e</b>
<b>29</b>	<b>Thermalito Power Canal at Hwy 70</b>	<b>Sensor/SCADA</b>	<b>e</b>
<b>30</b>	<b>Thermalito Forebay (north)</b>	<b>Profile</b>	<b>e,g</b>

31	Thermalito Forebay (south)	Profile	e,g
32	Thermalito Pumping-Generating Plant	Sensor/SCADA	e
33	Thermalito Afterbay (north)	Profile	e,g
34	Thermalito Afterbay (south)	Profile	e,g
35	Afterbay Outlet to Western Canal	Sensor/SCADA	e,h

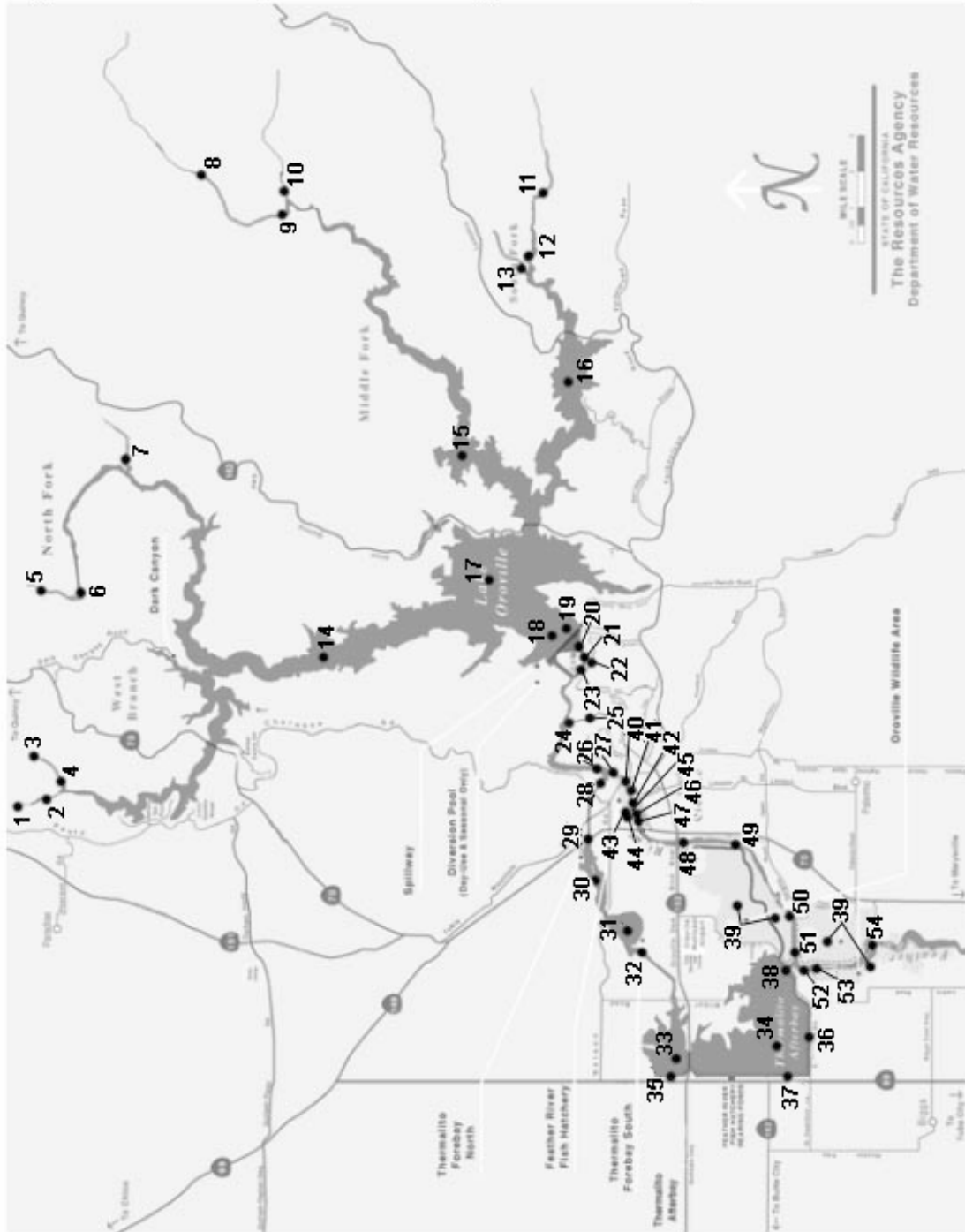
**Table SPW6-1. Temperature Measurement Sites in Project and Downstream Waters, continued**

36	Afterbay Outlet to Sutter Buttes Canal	Sensor/SCADA	e,h
37	Afterbay Outlet to PGE	Sensor/SCADA	e,h
38	Afterbay Outlet to Feather River	Sensor/SCADA	d,e,g,h,k
39	Oroville Wildlife Area Ponds	Profile	b
40	USGS Gage upstream from Fish Barrier Dam	Recorder	b,e
41	Fish Barrier Dam	Sensor/SCADA	e,I,j
42	Feather River above Hatchery	Recorder	d,e,I
43	Feather River Fish Hatchery	Sensor/SCADA	e,j
44	Hatchery Wastewater Pond	Recorder	k
45	Hatchery ditch	Recorder	k
46	Feather River downstream from Hatchery	Recorder	d,e,I,k
47	Feather River at Auditorium Riffle	Recorder	d,e,I,h
48	Feather River downstream from Hwy 162	Recorder	d,e,I,h
49	Feather River at Robinson Riffle	Recorder	d,e,I,h
50	Feather River at Eye Riffle	Recorder	d,e,I,h
51	Feather River upstream from Afterbay Outlet	Recorder	d,e,I,h
52	Feather River downstream from Afterbay Outlet	Recorder	d,e,h,k,L
53	Feather River downstream from SCOR Outfall	Recorder	k
54	Feather River near Mile Long Pond	Recorder	d,e,h,L
55	Feather River near Gridley	Recorder	d,e,h,L
56	Feather River upstream from Honcut Creek	Recorder	d,e,h,L
57	Honcut Creek	Recorder	e,k
58	Feather River near Live Oak	Recorder	d,e,h,L
59	Feather River upstream from Yuba River	Recorder	d,e,h,L
60	Yuba River at Marysville	Recorder	e,k
61	Feather River at Shanghai Bend	Recorder	d,e,h,L
62	Feather River at Star Bend	Recorder	d,e,h,L
63	Bear River	Recorder	e,k
64	Feather River near Nicolaus	Recorder	d,e,h,L
65	Feather River near Verona	Recorder	d,e,h,L

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|--------------------------------|----------------------------------------------------------------|
| a. Fisheries access, passage   | g. Temperature effects to water quality (e.g., Hg methylation) |
| b. Habitat quality, evaluation | h. Effects to agricultural beneficial uses                     |

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- |                                                    |                                                     |
|----------------------------------------------------|-----------------------------------------------------|
| <b>c. Inflow effects to reservoir temperatures</b> | <b>i. Biological Opinion temperature compliance</b> |
| <b>d. Endangered species concern</b>               | <b>j. Fish hatchery temperature agreement</b>       |
| <b>e. Temperature model calibration</b>            | <b>k. Discharge effects to river temperature</b>    |
| <b>f. Effects to stratification</b>                | <b>l. Basin Plan standards compliance</b>           |

Figure SPW6-1. Temperature monitoring locations for Project waters



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### Task 1B— Future Project Effects on Thermal Regime of Project Waters

The Engineering and Operations Work Group has prepared study plans that will develop the necessary tools to simulate the physical attributes of Oroville Facilities operations in support of studies involving changes or impacts to flow, water temperature, sediment transport, and power generation. The study plans will use or result in development of a model to simulate expected temperature conditions from potential future project operations.

Model calibration and verification will be dependent on use of existing data and additional temperature data collected under Task 1A of this study. In addition, model development will require stage/discharge relationships at key locations along the river. Presently, stage/discharge is determined near the project boundary along the Feather River only near Gridley. Discharge relationships may have to be developed for other sites along the Feather River for model development and calibration. Installation of equipment and development of rating tables at sites where additional discharge data are necessary for model development and calibration will be coordinated with the Engineering and Operations Work Group.

The temperature model will be used to evaluate effects from potential future project operations on the cold water pool in Lake Oroville, and daily water temperatures in the Thermalito Diversion Pool, Forebay, and Afterbay, and Fish Barrier Pool. The model will also be used to simulate hourly temperatures at designated control points in the project area of the Feather River due to potential future project operations. The temperature models for the Oroville Reservoir (study plan SP-E1.3), Thermalito Complex (study plan SP-E1.4), and Feather River (study plan SP-E1.5) will rely on data collected in this study plan for calibration and verification. This study will use output from the temperature model to determine compliance with applicable goals, criteria, or standards.

### Task 2— Project Effects on Water Temperatures Downstream from Oroville Dam

Effects of existing and future project operations, including water releases, on temperatures in the Thermalito Diversion Pool, Forebay, and Afterbay, Fish Barrier Pool, Oroville Wildlife Area ponds, and Feather River downstream to the Thermalito Afterbay Outlet will be assessed in Task 1. Effects of existing and future project operations on water temperatures downstream from the project boundary will be assessed in this task. This assessment will include water temperatures in the Feather River downstream from the Thermalito Afterbay Outlet, agricultural canals fed by the Thermalito Afterbay, and downstream agricultural diversions from the Feather River.

### Task 2A— Existing Project Effects on Thermal Regime Downstream from Project Boundary

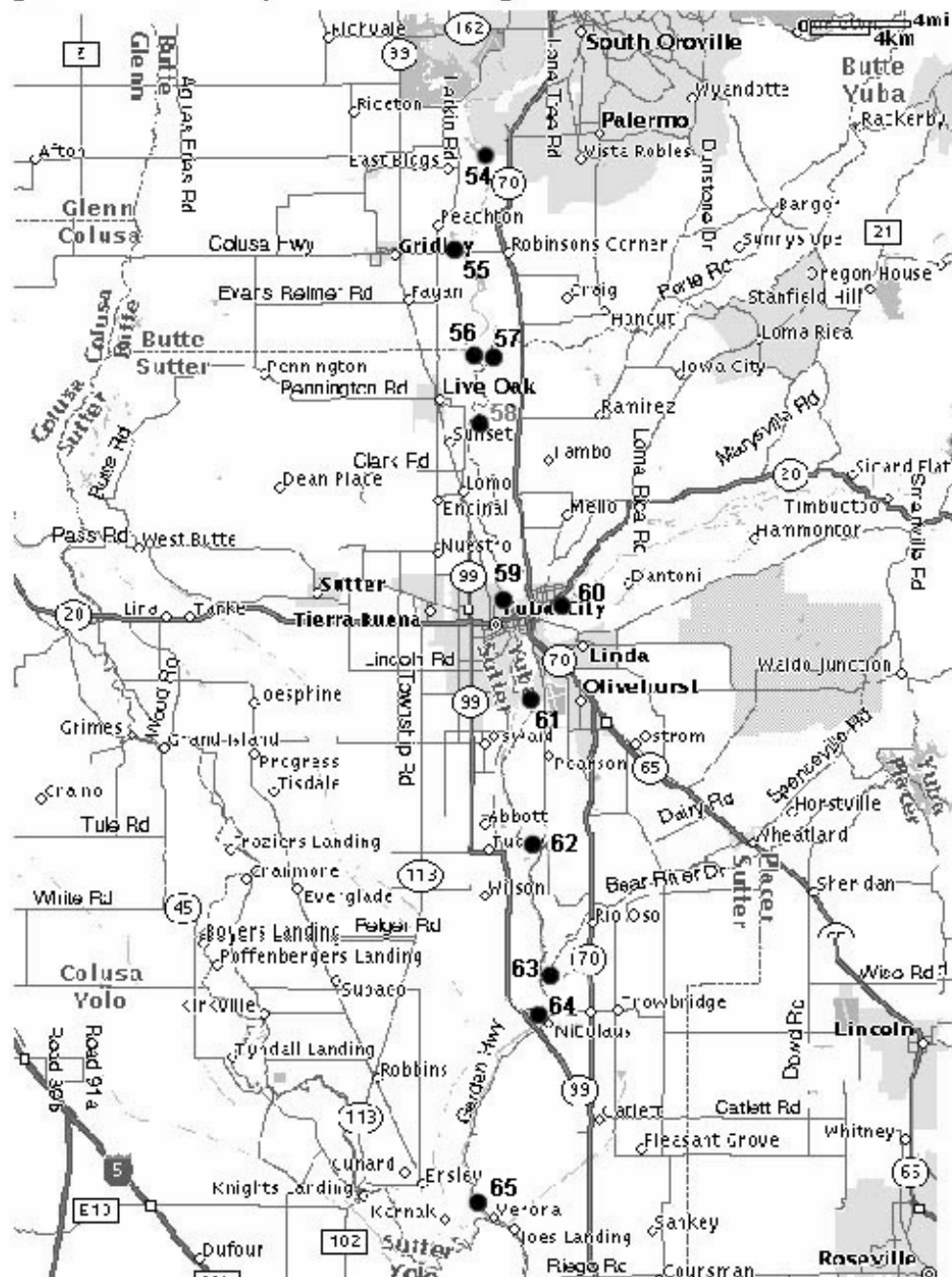
Temperature data will be collected at existing and additional monitoring sites downstream from the Afterbay Outlet (Figure SPW6-2) to provide information needed for analyses of existing project effects on the thermal regime in the Feather River and agricultural diversions. Continuously recording loggers (Onset Optic Stowaway) will be used to record temperatures at 15-minute intervals at the monitoring locations. Redundant recorders will be placed on opposite banks at critical sites to reduce potential loss of data. Temperature loggers will be serviced and data downloaded to lap top computers at intervals not exceeding monthly, but more frequently at sites where recorder loss is prevalent. Temperature data



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**from the river and diversions will be used to evaluate existing effects due to project releases from the dam and the Thermalito Afterbay.**

Figure SPW6-2. Temperature monitoring locations in the lower Feather River



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#### Task 2B—Future Project Effects on Thermal Regime Downstream from Project Boundary

The Engineering and Operations Work Group will develop a temperature model to simulate temperature conditions due to potential future project operations in the Feather River downstream from the Afterbay Outlet and in agricultural diversions from the Afterbay and river. Model calibration and verification will be dependent on temperature data collected under Task 2A. Model development will require stage/discharge relationships at key locations along the river and diversion canals. Presently, stage/discharge is determined along the Feather River only near Gridley, while stage only is measured near Live Oak, Yuba City, Boyd's Landing (downstream from Yuba City), and Nicolaus. Tributary stage/discharge measurements are also available from the Yuba River near Marysville and Bear River near Wheatland. Discharge relationships may have to be developed for the stage only gages or other sites along the Feather River for model development and calibration. Installation of equipment and development of rating tables at sites where additional discharge data are necessary for model development and calibration will be coordinated with the Engineering and Operations Work Group.

The temperature model will be used to simulate hourly temperatures due to potential future project operations at designated control points in the Feather River and agricultural diversions. Output from the temperature models for the Feather River (study plan SP-E1.5) will be used in this study to determine compliance with applicable goals, criteria, or standards.

#### Task 3—Project Effects on Temperature Compliance

Various agreements have established temperature requirements downstream from Oroville Dam. An agreement with the Department of Fish and Game specifies water temperatures at the Feather River Hatchery for raising Chinook salmon and steelhead, and between the Thermalito Afterbay Outlet and Verona to provide suitable temperatures during the fall for fall-run Chinook salmon and from May through August for shad and striped bass. The National Marine Fisheries Service issued a Biological Opinion in 2001 that included a temporary temperature objective that will avoid or minimize Oroville's adverse effect to spring-run Chinook salmon and steelhead between March 2001 and February 2002. This temporary objective was to maintain water temperatures in the low flow channel from June 1 through September 30, 2001 to a daily average temperature of no more than 65 °F to protect over-summering steelhead. A new Biological Opinion is expected in March 2002 that will likely also include temperature objectives from June through September of 2002 and 2003. DWR and NMFS also expect to develop a long-term Biological Opinion that would likely include temperature objectives after March, 2004. An additional agreement with several irrigation districts concerns suitable water temperatures for maintaining agricultural production with water diverted from the Thermalito Afterbay and Feather River (DWR 1969). Though the agreement does not specify desired temperatures, germination and early growth of rice requires temperatures of about 65 °F from about April through mid-May, and at least 59 °F during the remainder of the growing season (IIP 2001). In addition, the CVRWQCB Basin Plan has designated beneficial uses for the Feather River from the Fish Barrier Dam to the Sacramento River as cold freshwater habitat, salmon and steelhead migration, and salmon and steelhead spawning.

#### Task 3A—Existing Project Effects on Temperature Compliance

Effects of existing project operations on fisheries and agriculture temperature compliance will be evaluated with data obtained in Tasks 1 and 2. Data obtained from these tasks will be compared to the

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temperature requirements in the various agreements, Biological Opinions, and Basin Plan to determine project compliance.

Task 3B—Future Project Effects on Temperature Compliance

The temperature model developed in Task 1 will be used to simulate temperature conditions due to potential future project operations in the Feather River. This simulation will be used to determine compliance of future project operations with the temperature agreements, Biological Opinions, and Basin Plan.

Task 4—Access to Cold Water Pool

Water temperatures in the Feather River downstream from Oroville Dam are regulated by a temperature control intake structure. This structure consists of a series of shutters that are removed to withdraw water down to a specific depth in the reservoir. As the reservoir level decreases, additional shutters are opened to maintain downstream temperatures. Drought years reduce the cold water pool available for downstream release. The intake structure controls the lake level from which water is withdrawn to supply water to the hatchery and low-flow channel for temperature maintenance. Since all controlled water releases from the reservoir pass through the intake structure, water released for downstream water supply and power generation is obtained from the same depths as that for temperature maintenance at the hatchery and low flow channel, which further reduces the cold water pool.

Task 4A—Existing Project Effects on Cold Water Pool

Current data collection activities include monthly temperature profiles in the reservoir near the intake structure, daily reservoir water levels, daily reservoir releases, and several sites in the Feather River downstream from the dam to the Sacramento River. Temperature data from thermistors positioned on the intake structure every 18 to 19 feet from the 612 to 819 foot elevation are recorded once per month. The frequency of temperature recording from the thermistors will be increased to daily.

Additional monthly temperature profiles will be obtained in other areas of the reservoir (Figure SPW6-3) using the methods specified in Task 1A to determine whether intake structure withdrawals produce local or wider ranging effects to water column temperatures. The depicted profile locations in Figure SPW6-3 may be modified or additional locations added depending on results of the initial temperature measurements. Water column effects from intake structure operations will be determined by comparing temperature profile graphs near the intake structure with those obtained further away. Temperature profiles will also be obtained at the profile monitoring locations preceding and following pump-back operations to determine effects to water column temperatures.

Previous reservoir temperature data, additional reservoir temperature data collected during this study, reservoir water level data, reservoir releases data, and downstream temperature data will be used to evaluate the effects of the project on the cold water pool and the effectiveness of the project in meeting temperature requirements during various water year types.

Information collected in this task will be used by the Engineering and Operations Work Group in evaluating the availability of the cold-water pool in Oroville Reservoir to control downstream

temperatures under a variety of operational and climatic conditions. The data from this study will be used to calibrate and verify models used in study plan SP-E7 by the Engineering and Operations Work Group.

**Figure SPW6-3. Illustrative temperature monitoring sites (•) near the Temperature Control Intake Structure**



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#### Task 4B—Future Project Effects on Cold Water Pool

Water temperature data collected in Task 4A will be used to calibrate a temperature model for the reservoir developed in the Engineering and Operations Work Group study plan SP-E7. The reservoir temperature model will be used to evaluate effects from a variety of potential operational and climatic conditions and future project operations on the cold water pool in Lake Oroville and temperature of water released from the reservoir. The river temperature model developed in study plan SP-E1.5 will be used to simulate hourly temperatures at designated control points in the Feather River resulting from reservoir release temperatures. The river temperature simulations will be used in this study to develop a water temperature management plan and determine the ability of the project to comply with the various temperature goals, criteria, or standards.

#### Task 5—Hatchery Effects on Water Quality)

The depth at which water is released from the reservoir to provide suitable temperatures at the fish hatchery also controls the temperature of the water in the low flow section of the Feather River and water diverted to the Thermalito Afterbay for release to agricultural users. Similarly, the quality of water released to the low flow channel and the Afterbay is controlled by the quality of water at the depth of release from the reservoir to maintain hatchery temperatures. In addition, chemicals used at the hatchery and fish waste products are diverted to holding ponds that percolate into the ground, which then may leach to the adjacent Feather River. Water quality effects to the Feather River from the hatchery are analyzed in **SP-W4**, while effects from reservoir withdrawal elevations are analyzed in **SP-W1**. Hatchery effects on temperatures are analyzed in this study plan.

#### Task 5A—Existing Hatchery Effects on Water Quality

This study plan evaluates the existing effects to beneficial uses of water released from Oroville Dam to maintain water temperatures at the hatchery, and effects to water temperatures in the Feather River from hatchery discharges.

Evaluation of the existing effects to beneficial uses of water released for maintenance of temperatures at the hatchery will use data collected in Tasks 1 and 2. The data will be compared to temperature agreements for fisheries and agriculture, Basin Plan Standards, and Biological Opinions.

The fish hatchery does not directly discharge to the Feather River. However, water leaching to the Feather River from percolation in the wastewater holding ponds could affect water temperatures in the river. Evaluation of the effects of hatchery discharges through percolation of wastewater on temperatures in the Feather River will use data collected in Task 1. Additional temperature data along the Feather River adjacent to the hatchery will be collected with a thermistor to help determine locations of hatchery water leaching to the river. Upstream and downstream water temperatures will be compared to determine effects from the hatchery. Any changes in temperature due to hatchery discharges will be compared with the temperature objectives for fisheries and agriculture, Basin Plan Standards, and Biological Opinions to determine their significance.

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#### Task 5B—Future Hatchery Effects on Water Quality

Hatchery operations are presently undergoing review. Results of this review will be evaluated to determine any changes in hatchery operations that may affect water temperatures. The temperature model developed in study plan SP-E1.5. will be used to simulate the effects of any future altered hatchery operation on water temperatures in the Feather River. Model simulation results will be used to determine effects to beneficial uses as described in the Basin Plan, temperature agreements, and Biological Opinions.

#### Task 6—Effects of Pump-back Operations

Water can be pumped back from the Thermalito Afterbay, Forebay, and Diversion Pool for reuse in power generation based on power economics. Water from the Diversion Pool is discharged into the reservoir through the temperature control intake structure. Potentially warmer water from the Diversion Pool can disrupt the reservoir temperature profile near the intake structure. In addition, potentially warmer water pumped back into the Diversion Pool can be released to the low flow section of the Feather River that may affect hatchery operations and fisheries in the river.

#### Task 6A—Existing Effects of Pump-back Operations

Water temperature data for evaluation of existing effects of pump-back operations in the reservoir and river will be obtained from Tasks 1 and 4. In addition, water profile temperatures will be measured in the Thermalito Diversion Pool, Power Canal, Forebay, and Afterbay immediately preceding and following pump-back operations to determine the effects on the temperature regime in these impoundments. A range of pump-back operations (e.g., volume of water pumped, duration of pumping) and temperature conditions (e.g., early summer, mid-summer, late summer) will be monitored to determine pump-back and temperature conditions that produce critical effects. The data will be compared with the various temperature agreements, Basin Plan Standards, and Biological Opinions to evaluate effects from pump-back operations on beneficial uses.

Effects from pump-back operations on water temperatures at the hatchery will be evaluated using temperature and pump-back records from historic operations, as well as data obtained during this study. Water temperatures at the hatchery will be compared prior to and following pump-back operations to determine whether any changes in temperatures occurred. These records will be compared for a range of pump-back operations and temperature conditions. These comparisons will be presented in graphical format.

#### Task 6B—Future Effects of Pump-back Operations

A temperature model may be developed by the Engineering and Operations Work Group in study plan SP-E8 to evaluate impacts of pumpback operations on the coldwater pool in Oroville Reservoir under various climatic and hydrologic conditions if data from Task 6A indicates an impact to reservoir temperatures. The results of the model simulation, if developed, will be used to determine compliance with various temperature agreements, Basin Plan Standards, and Biological Opinions.

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#### Task 7—Progress Report

A progress report will be prepared at the conclusion of the first year of study. Interim output products will be identified through coordination with other Work Groups to meet their data needs.

#### Task 8—Final Report

A final report will be prepared following completion of the second year of the study.

## **6.0 Results and Products/Deliverables**

### *Results*

Results from this study will be used to evaluate effects of the project on water temperatures both within and downstream from project boundaries. Data obtained from the study will also be used to develop a water temperature management plan and determine the ability of the project to meet temperature requirements for protection of beneficial uses, including agriculture, fish, and other aquatic resources.

Results from this study will be presented in a detailed report that evaluates existing and future effects of the project to water temperatures. Historical and current temperature data will be presented in graphs depicting the thermal regime in different water year types, for which data are available, for project waters and the Feather River downstream from the project. Graphs will depict thermal stratification in Lake Oroville, Thermalito Diversion Pool, Forebay, and Afterbay, and Oroville Wildlife Area ponds. Effects of the intake structure and pump-back operations on water column stratification in Lake Oroville will also be depicted in graphs for different periods and levels of withdrawal and pumping. Graphs depicting conditions in the Feather River downstream from Oroville Dam will illustrate daily maximum, minimum, and mean daily temperature variations (based on 15-minute data collected to compute hourly values) over the course of the year at key locations, such as the hatchery or agricultural diversion points. Graphs will also depict how temperatures in the Feather River change from the upper to lower reaches.

Output from the temperature model will be in the form of curves or graphs (e.g., exceedance curves, temperature vs. time of year at key locations, temperature vs. river mile, etc.) that can be used to evaluate future project effects. Additional model output will be coordinated with the Environmental Work Group, Task Force, and regulatory agencies to provide information in the format these groups may require for analysis of effects. This analysis will be dependent on any decisions that necessitate changes in project operations, and may not be available until completion of other studies or negotiations.

Compliance with the various temperature agreements, Basin Plan Standards, and Biological Opinions will be used to evaluate both existing and future effects of the project to water temperatures. Information derived from this study will be used by the SWRCB to determine conditions in the water quality certification to comply with Section 401 of the Federal Clean Water Act.



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## 7.0 Coordination and Implementation Strategy

### *Coordination with Other Resource Areas/Studies*

This study plan coordinates with data collection activities of study plan SP- #W1—(Project Effects on Water Quality Designated Beneficial Uses) and study plan SP-#W4—(Hatchery Effects on Water Quality). This study

plan provides temperature data to the Engineering and Operations study plans SP-E1.3, SP-E1.4, SP-E1.5, SP-E6, SP-E7, and SP-E8 for temperature model calibration and verification, and will rely on the temperature model developed in those study plans to provide temperature simulations for evaluation in this study plan of future effects of the project to water quality. In addition, this study plan provides data for evaluation of effects of water temperature to habitat suitability and fisheries in Fisheries study plan SP-#F10 (Appendices A and C), and SP-#F15.

### *Issues*

This study plan provides the information for evaluation of Issue Statements W9—thermal regime of project waters, W10—project effects on water temperatures downstream from Oroville Dam, W11—project effects on temperature compliance, W12—access to cold water pool, W13—hatchery effects on water quality, and W14—effects of pump-back operations. This study fully or partially addresses the following Stakeholder issues:

#### *Stakeholder issues fully addressed by SP-W6 Project Effects on Temperature Regime*

- **WE16.** Depth and capacity of the Oroville reservoir creates a thermally stratified condition. What is the cold-water pool retained in the basin and what is its availability for release in various water year types
- **WE17.** Water temperatures are an issue of concern for both aquatic resources and agricultural interests. Temperature monitoring is ongoing, and plans are to examine how specific water releases operations will affect temperatures in the river, Afterbay, and hatchery
- **WE18.** Are the existing temperature requirements defined under the State Water Projects Feather River Flow Constraints being met and are they adequately protecting steelhead and fall, late-fall, and spring-run Chinook salmon in the low-flow section and in the river downstream of Thermalito Afterbay outlet

#### *Stakeholder issues partially addressed by SP-W6 Project Effects on Temperature Regime*

- **WE19.** Is the availability of a cold-water pool in Lake Oroville adequate under present and future operational demands to meet the existing downstream cold fresh-water habitat requirements of steelhead and fall, late-fall, and spring-run Chinook salmon?
- **WE21.** Is the availability of a cold-water pool in Lake Oroville adequate under present and future operational demands to meet the cold-water requirements defined under the State Water Projects Feather River Flow Constraints for the Feather River Hatchery?
- **WE22.** Does the existing Temperature Control Device (TCD) in Lake Oroville provide adequate access to the cold-water pool during below normal water or drier years?

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- **WE23.** Will the existing TCD in Lake Oroville provide adequate access to the cold-water pool under future operational demands particularly during a series of dry and critically dry years?
  - **WE25.** Does the present temperature model have the ability to forecast average daily water temperatures, under present and future operational demands, in the low-flow channel and in the river from the Thermalito Afterbay outlet down to Verona?
  - **WE26.** How does the Feather River Hatchery requirement for warmer water in the summer impact river water temperatures required for holding or rearing of steelhead and spring-run Chinook salmon in the low-flow section? That is, should the hatchery water come directly from Lake Oroville rather than from the river at the Fish Barrier Dam in order that both hatchery and river temperature needs can be satisfied
  - **WE27.** How does the pump-back operation during the summer months affect water temperatures required for holding and rearing of steelhead and spring-run Chinook salmon in the low-flow section and in the river downstream of Thermalito Afterbay?
  - **WE32.** Thermalito Afterbay acts as a thermal retention basin for project water prior to delivery to water districts outside the project boundary. How do releases from this water body affect the stream temperature and dissolved oxygen content of Feather River receiving waters?
  - **WE33.** Relationship between hatchery and water quality
  - **WE40.** Minimum level of drawdown effect on water temps
  - **WE46.** Spawning habitat in tributaries as they relate to operations
  - **F1.** Effects of existing and future project operations (including power generation, water storage, ramping rates, and releases, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates), which include in project waters and tributaries within the project boundaries (Lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters:
  - **F3.** Project effects on resident fish species (e.g., trout and other salmonids and warm-water fish) habitat quantity and quality (including instream flow, sediment, woody debris, water temperature, etc.,) and habitat for other aquatic species
  - **F11.** Compliance of project operations with SWP Feather River Flow Constraints and adequacy of constraints to protect anadromous fish and other aquatic species in the low-flow section and in the river downstream of the Afterbay
  - **FE3.** Is the present minimum pool adequate for protecting the Lake Oroville cold-water sport fishery?
  - **FE46.** Clearly identify species, landowners along river, flow rates and temperature requirements downstream of the dam.
  - **FE56.** The Feather River's low-flow reach has historically provided spawning habitat for a cold-water fishery. How have reduced flows to this stream reach affected water temperature and gravel substrate necessary for successful salmonid reproduction?
  - **FE88.** Impact of hatchery facilities and/or operations on anadromous salmonids. This includes the direct, indirect and cumulative impacts of hatchery product on anadromous salmonids and the direct, indirect and cumulative impacts of hatchery facilities and operations on salmonids and their habitats.

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- **FE89.** Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitats;
  - **FE90.** Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats;

#### **Indirect**

- **WE20.** Are the existing temperature requirements defined under the State Water Projects Feather River Flow Constraints adequate for the operation of the Feather River Hatchery?
- **WE28.** Does the increase in river water temperature that results from warmer Thermalito Afterbay releases during the spring, summer, and fall months limit the amount of suitable steelhead and salmon habitat in the river downstream of Thermalito Afterbay?
- **WE29.** Does the increase in river water temperature that results from warmer Thermalito Afterbay releases during the spring and early summer months affect survival of salmonid species outmigrating from the Feather and Yuba River
- **WE54.** Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitat. Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats
- **F9.** Hatchery effects (e.g., straying, genetic impacts, harvest rates, disease, temperature requirements, interactions with native fish such as predation and competition) on salmonid populations in the Feather River watershed and other Central Valley tributaries and on ecosystem restoration within project waters and project affected waters
- **F10.** Effect of existing and future project facilities and operations on anadromous fish habitat and populations (e.g., instream flows, water temperature, ramping rates, riparian habitat, large woody debris, predation, spawning gravels, stranding and desiccation, macroinvertebrate prey base, upstream and downstream passage, rearing conditions)
- **FE8.** Lake Oroville releases made for power generation may cause dramatic fluctuations in lake level. What are the potential impacts of fluctuation zone and surface elevation change on recreation opportunities and on fish and wildlife habitat?
- **FE33.** Are the present streamflows defined under the State Water Projects Feather River Flow Constraints being met and are they adequately protecting steelhead and fall, late-fall, and spring run Chinook salmon in the low-flow section and in the river downstream of Thermalito Afterbay for migrating, holding, spawning, and rearing of steelhead and fall, late-fall, and spring-run Chinook salmon;
- **FE41.** Early on and clearly identify flow rates and temperature requirements downstream of the dam; **FE41.** Early on and clearly identify flow rates and temperature requirements downstream of the dam;
- **FE49.** Incidence of fish disease in response to temperature changes below dam;
- **FE52.** Facility operations and impact – on bass fishery and spawning activities at afterbay (protect and enhance bass fishery);
- **FE81.** Currently some of the species of fish commonly found in Lake Oroville are also found in the Poe reach of the North Fork Feather River. Maximum water temperatures in the Poe reach often exceed 20 C (68 F), making management of the Poe reach as a coldwater fishery difficult. There is an

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interest in determining the interaction of the Lake Oroville fishery with the Poe reach fishery, and identifying measures that can be taken to maintain the Poe reach as a coldwater fishery;

- **FE85.** Impact of project facilities and operations on fish passage includes structures, flows, and/or water quality conditions that impede or block passage within and from current and/or historic habitat and operations that impact passage or have the potential to enhance passage. Passage includes movement of spawning or holding adults, emigrating smolts, or movement of juveniles to different habitat areas for purposes of feeding, avoiding predators, or sheltering;
- **FE95.** The lower Feather River provides habitat to support a variety of anadromous fish species including Chinook salmon, steelhead, striped bass, American shad and sturgeon. Potential changes in license conditions could adversely impact habitat supporting these species. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of anadromous species including flow, water temperature, instream and riparian cover, substrate and spatial area;
- **FE96.** The lower Feather River provides habitat to support a variety of resident native and resident introduced species including coldwater species such as rainbow, brook, and brown trout, and warm water species such as bass, catfish, bluegill, green sunfish, carp and others. Potential changes in license conditions could adversely impact habitat supporting these species or upset habitat conditions such that less desirable species are favored. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of these resident native and non-native species including flow, water temperature, instream and riparian cover, substrate and spatial area;
- **FE99.** The Feather River Hatchery was constructed to mitigate for losses of upstream habitat when the Oroville facilities were constructed. There is a body of evidence suggesting that improperly planned hatchery practices can adversely impact native and non-native species including anadromous species. The effects of hatchery practices on naturally reproducing/self sustaining anadromous populations should be examined as part of the fishery investigations. These evaluations should examine alternative practices that would lead to increased naturally reproducing/self-sustaining anadromous populations. Improper hatchery practices can also lead to transmission of serious fish diseases, and impact overall susceptibility of naturally reproducing populations to diseases.

## **8.0 Study Schedule**

Data collection activities will begin in early 2002 and continue for at least two years. Concurrently, the temperature models will be developed by the Engineering and Operations Work Group, and will be available by the end of August of 2002. Information developed will be presented quarterly to the Environmental Work Group and Task Force for review to evaluate the adequacy and progress of the study. A progress report will be prepared in early 2003 after completion of the first year of monitoring. The progress report will review results, evaluate the adequacy of the monitoring program, and recommend changes to the second year of the monitoring program, which may include reduction or elimination of certain parameters and addition or increased frequency of monitoring for others. A draft final report discussing results of the two-year study will be prepared by June of 2004.

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## **9.0 References**

**DWR 1969. Agreement on diversion of water from the Feather River. Department of Water Resources. Sacramento, California.**

**DWR 2001. Initial Information Package for Relicensing of the Oroville Facilities. Federal Energy Regulatory Commission License Project No. 2100. Department of Water Resources, Sacramento**